SPIRAL II HIGH INTENSITY RADIO FREQUENCY COOLER

a.k.a. SHIRaC

STATUS REPORT

SHIRAC COLLABORATION

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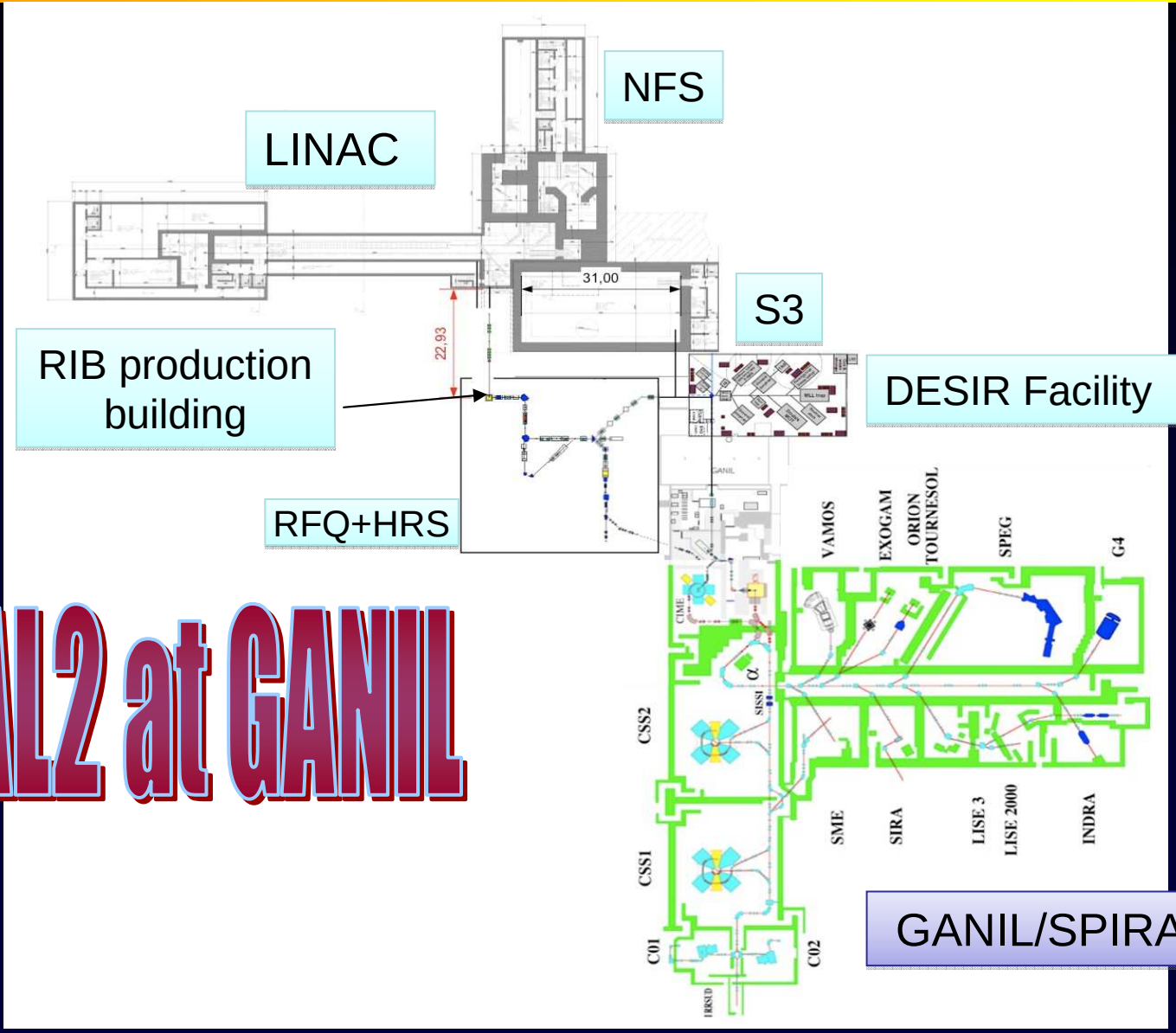
• MC Gill Univ.	B. MOORE
• GANIL	M. LEWITOWICZ, M. DI GIACOMO
• LPC CAEN	R BOUSSAID, G BAN, F BOUMARD, JF CAM, F. DUVAL Y MERRER, JM GAUTIER†, P. DESRUES, R. BUISSON,J. BREGEAULT, C. VANDAMME

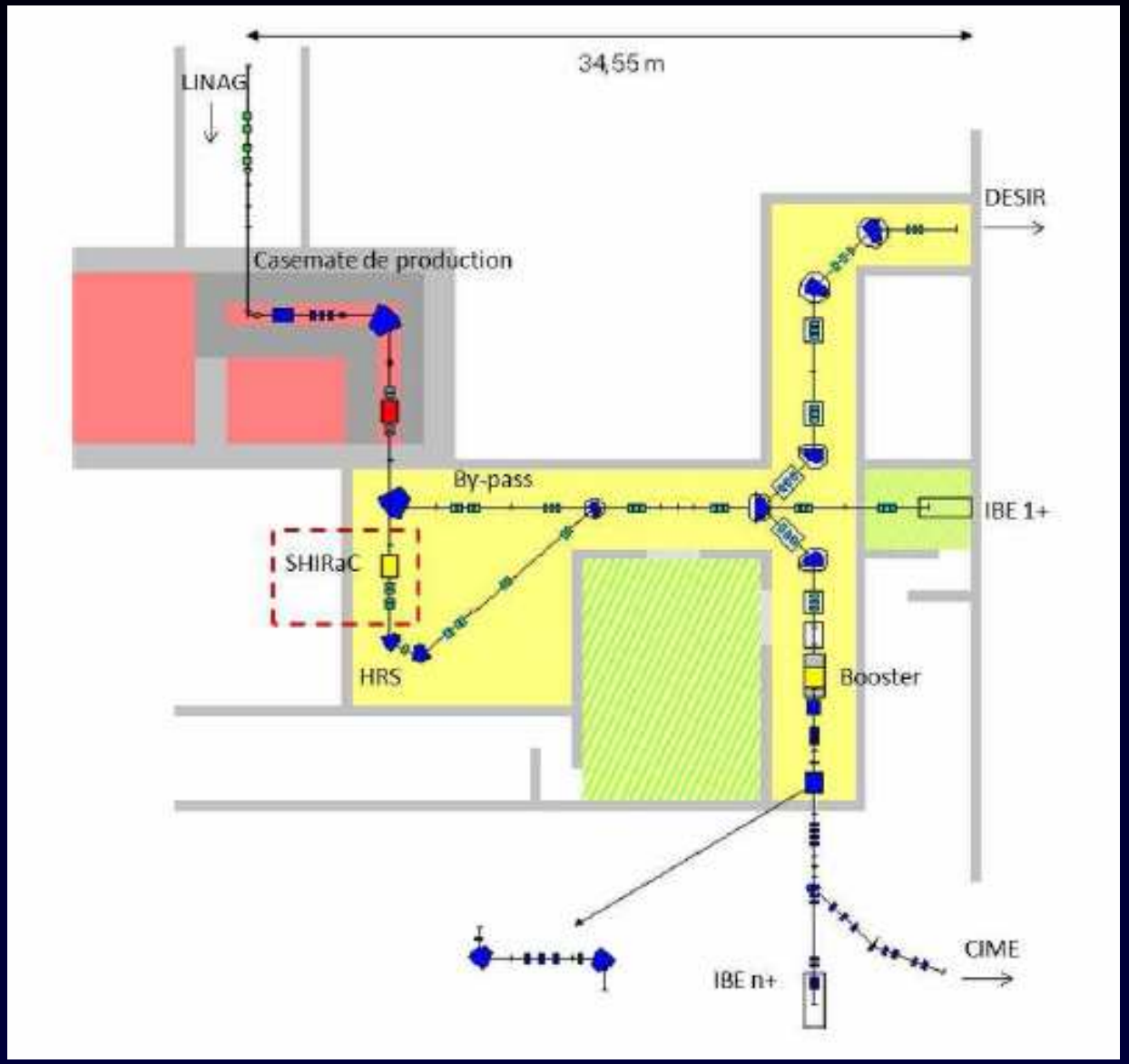
OUTLINE

- DESIR@SII
- Why/how cooling ?
- RFQ cooler principle
- Status and recent results
- 2010
- Conclusion

DESIR@SII


NFS
LINAC
S3
RIB production building
DESIR Facility
RFQ+HRS
31,00
22,93
SPIRAL2 at GANIL
VAMOS
EXOGAM
ORION
TOURNESOL
SPEG
G4
CIME
SSS1
CSS2
SME
SIRA
LISE 3
LISE 2000
INDRA
CSS1
C01
C02
IRSN/D
GANIL/SPIRAL 1

Why & How Cooling the beam?



WHY & HOW COOLING the beam?

- Requirements for High Resolution Spectrometer (HRS):
  low emittance to reach best performances

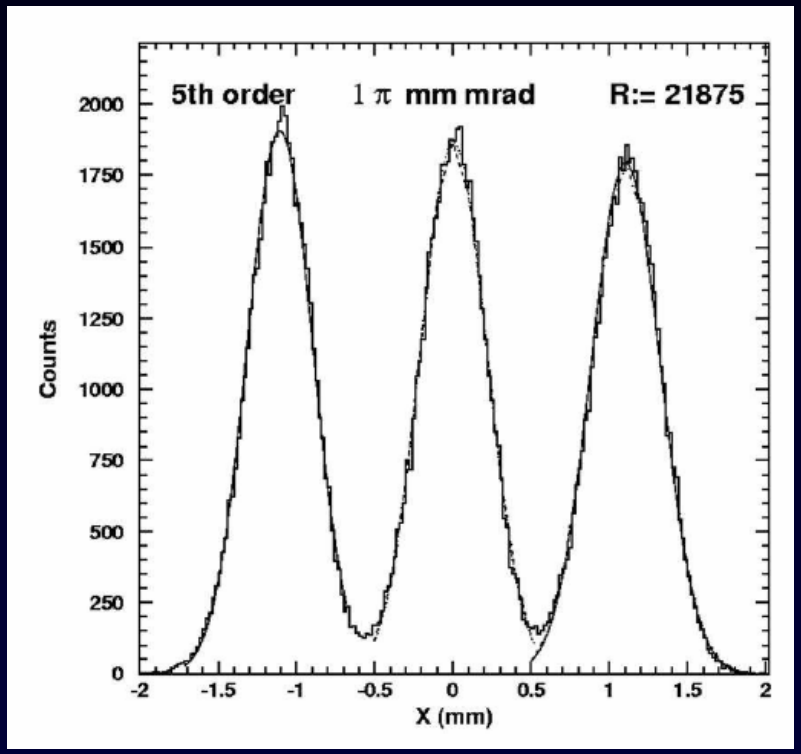
  HRS needs ~1 π mm mrad
  Ion source (ECS) ~ few 10 π mm mrad

- BUFFER GAS TECHNIQUE + RF for beam guiding
  (R.B. Moore O. Gianfrancesco NIM B 204 203)

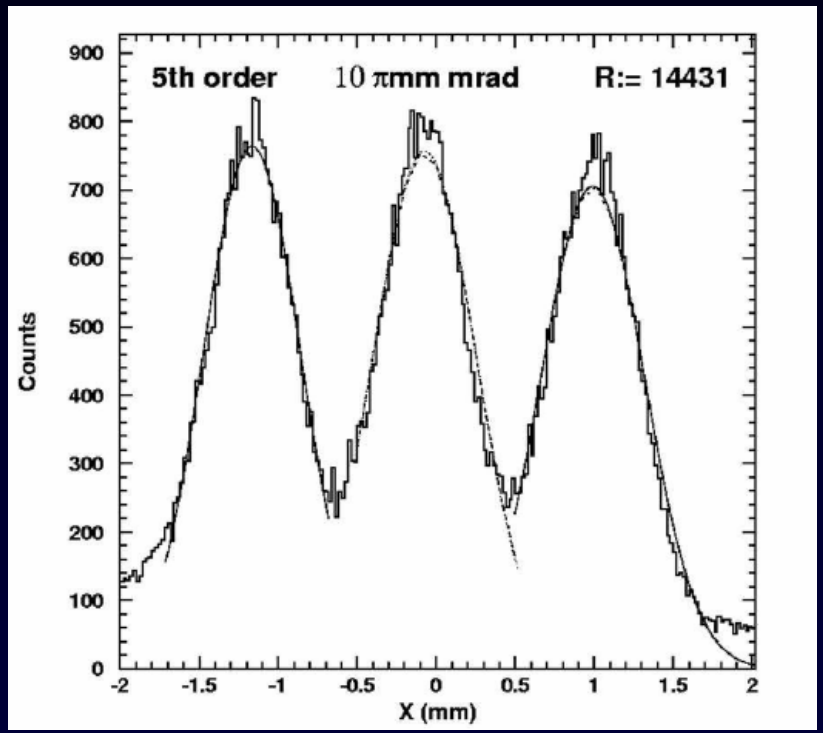
- The new challenge: Cooling of high intensity beams (μA)
  with high transmission

Beam emittance and resolving power

Calculation by T. Kurtukian Nieto
(With OLD HRS configuration)



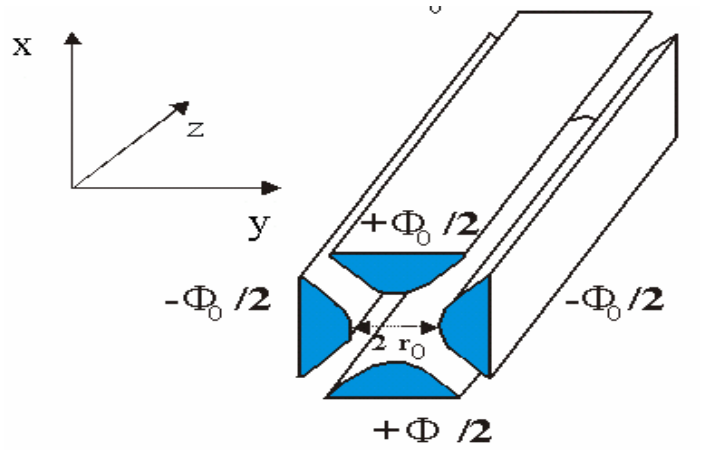
R ~22000



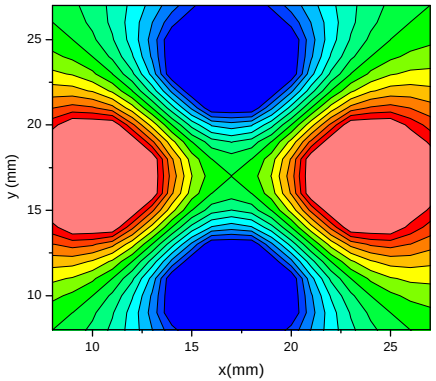
R ~14400

RFQ (radio frequency quadrupolar) cooler Principle

- Ion cooling by collisions on a light buffer-gas
  Helium 5-10 torr
  T_{ion} ~ 100eV (setup on HV platform)
- Axial DC potential for guiding and extraction
- RF Radial confinement



$$V(x,y) = V_0 \cdot \frac{(x^2 - y^2)}{r_0^2}$$



- High intensities -> Space Charge has to be compensated by high RF electric fields ($E^{1,5} \alpha I$)
- High electric fields can be obtained with small r_0 and much higher RF amplitudes

STATUS

Work achieved in 2009

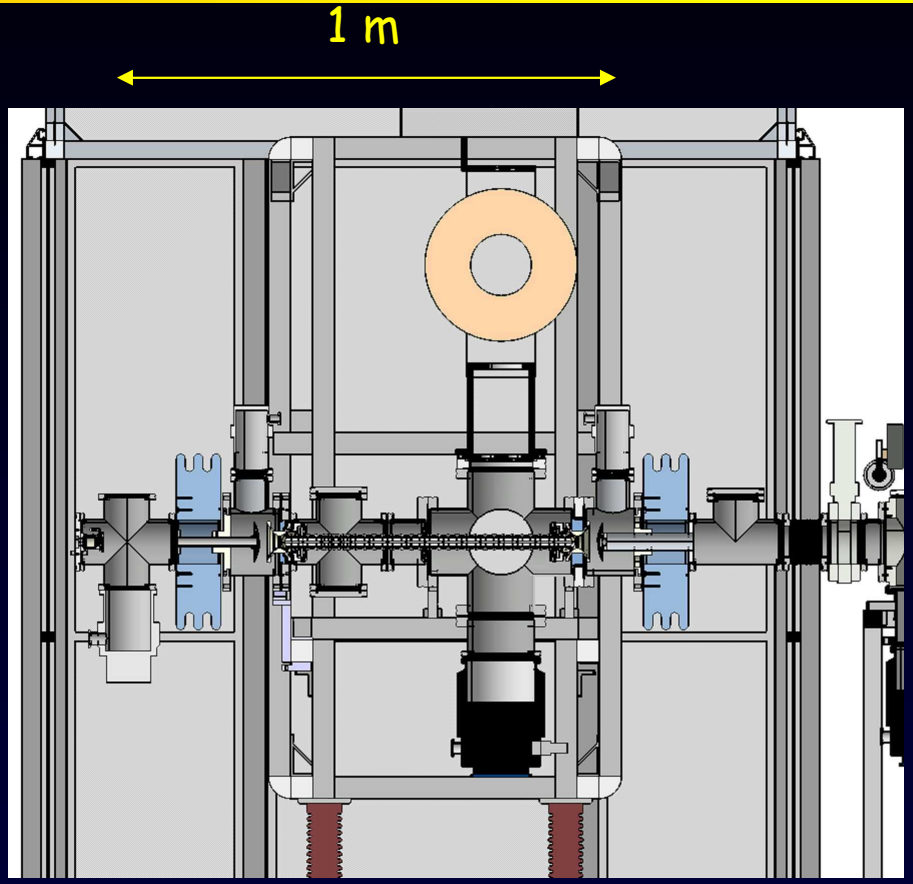
- Last tests on the modified prototype I
  (transmission & emittance measurements)
- Manufacturing of New Cooler
- Improved RF system
- Slow control
- New Cooler set up at LPC

PROTOTYPE SHIRAC I

Prototype I
CSNSM/McGill

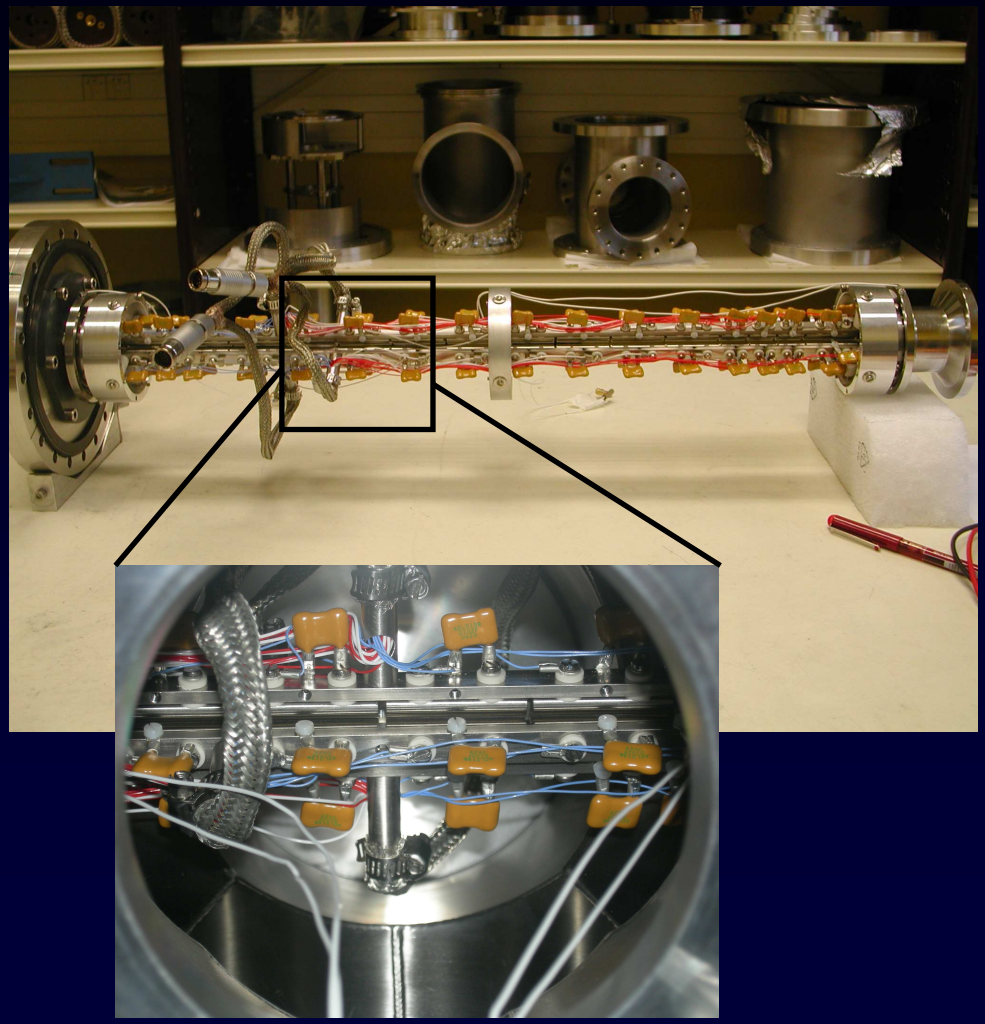
Mostly built for injection studies
R0=3mm L=500mm
(not complete at the end of 2007)

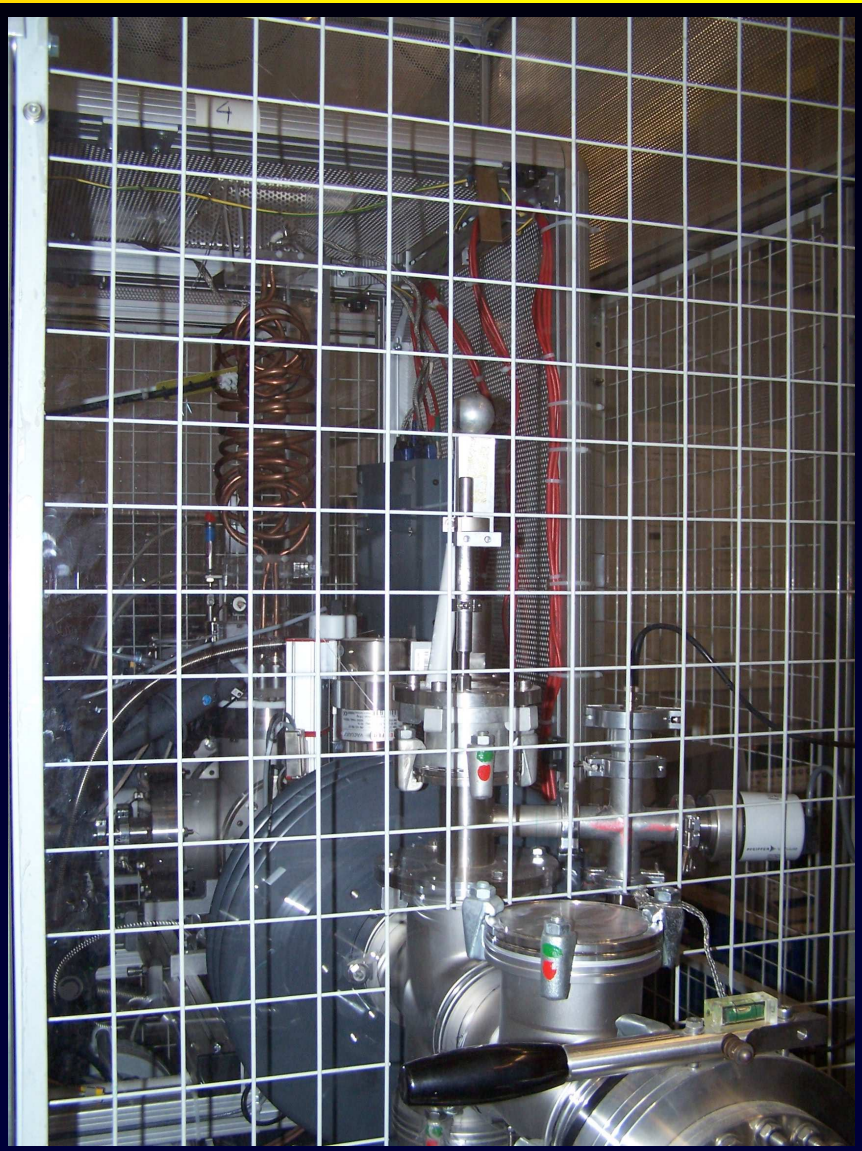
2007 Moved at LPC
2008 Set up and modifications
2008-2009 RF system development
2009 Additional pumping, Gas injection
Transmission & emittance measurements with small r_0 and high RF voltages



Pictures

R_0=3mm, L= 500mm

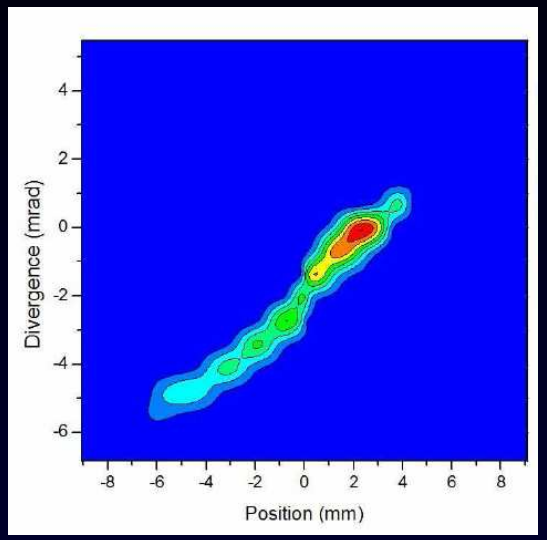


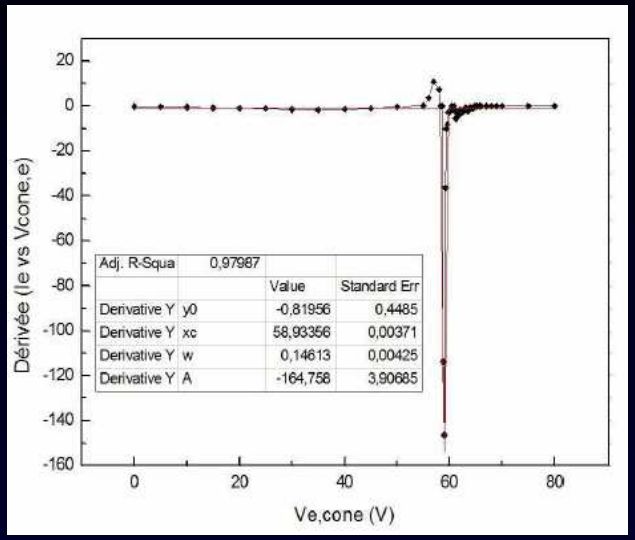


Last Tests with SHIRAC I (PhD Thesis F. Duval 2009)

Alkali Ion gun 3keV
I = 25 nA

RF: 1800 Vpp @5MHz
He : 0. 5Pa
HT = 2900V

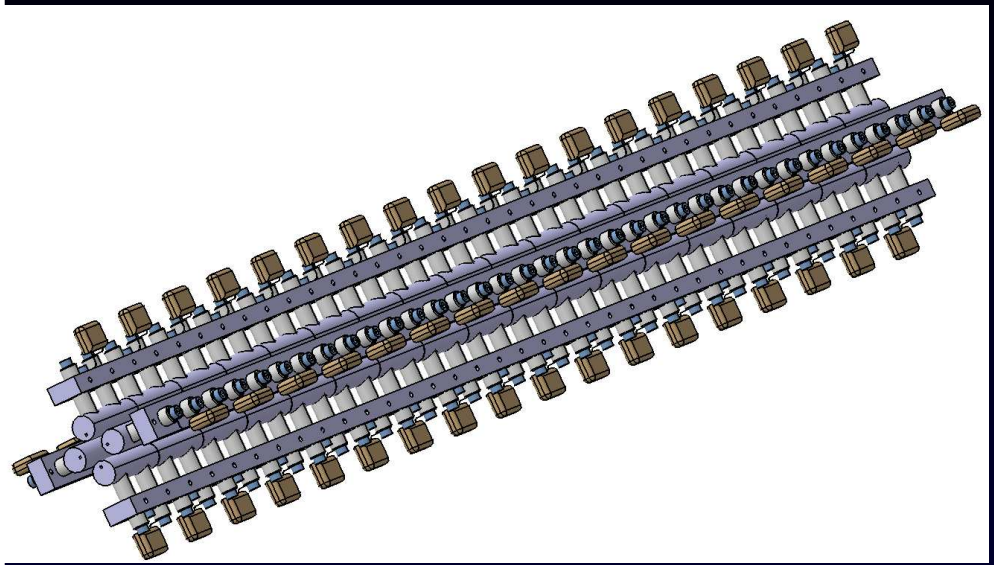




ε=2 pi mm mrad @ 60 keV
ΔE = 0.145 eV
Transmission = 25%

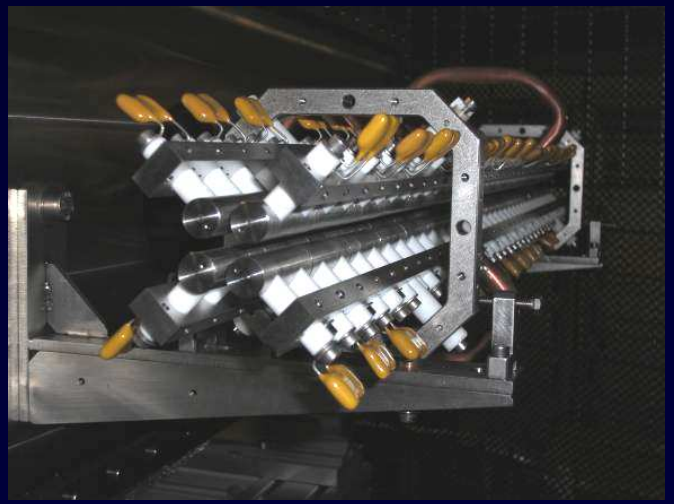
- Very promising results (to be confirmed with prototype II and higher intensity)
- Good agreement with simulations (space charge & Microscopic approach)
- Simulations show that the transmission is limited by the acceptance (r_0)

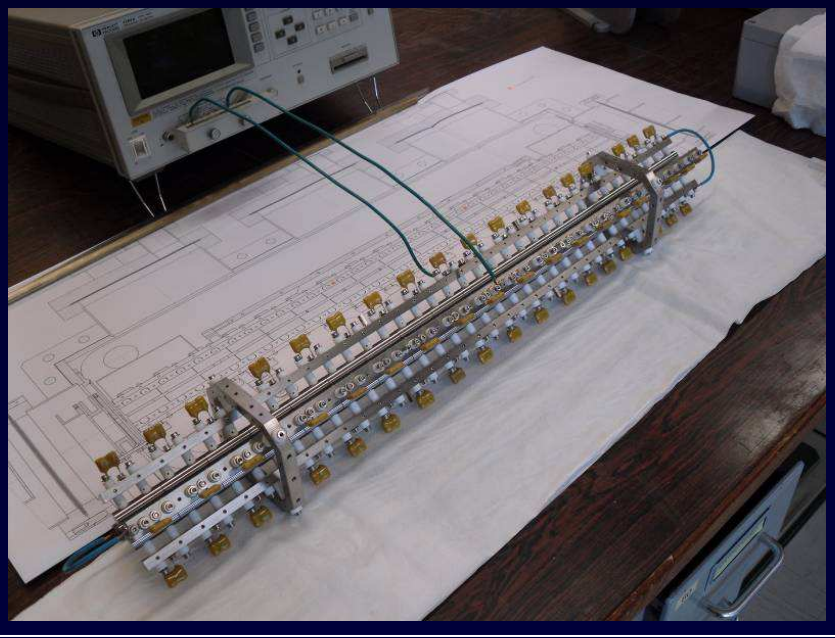
New cooler manufacturing and assembling (end 2009)



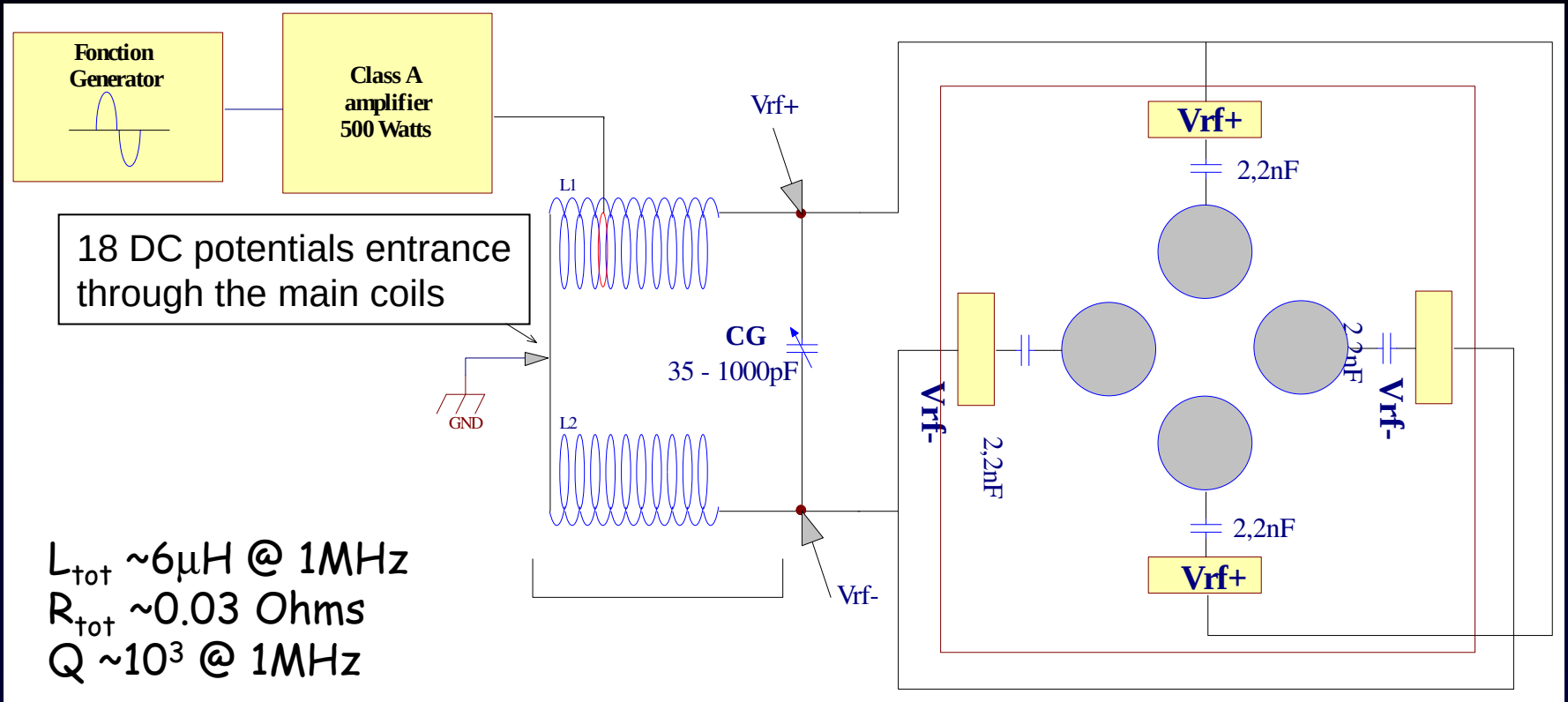
Simulated with
SC & Microscopic approach
(No SC neutralization)

à <u>Requirements:</u> 700 mm long
R_0=5 mm
10 MHz RF
10 kV_{ptp}



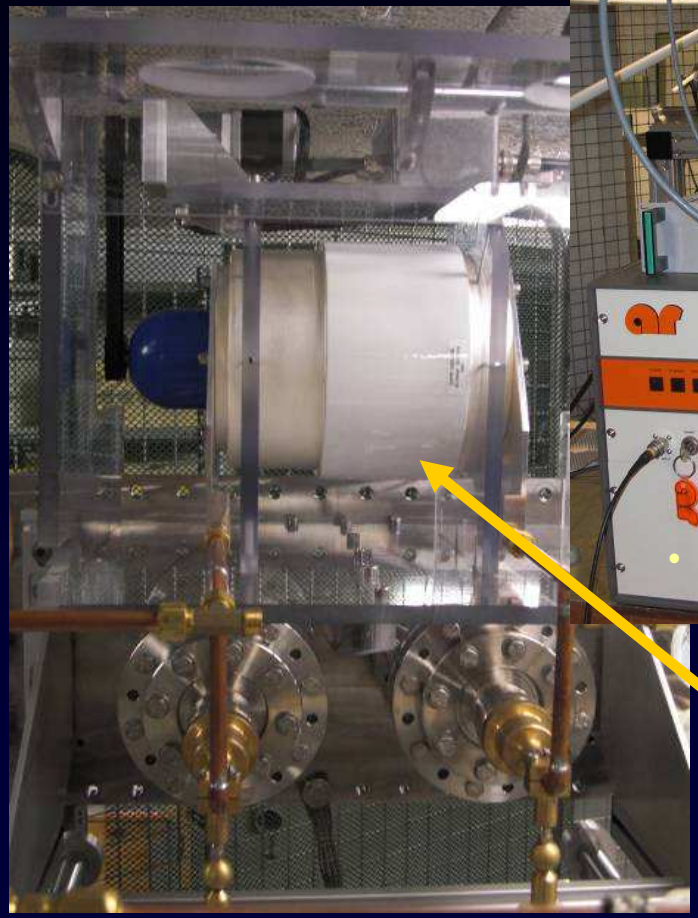


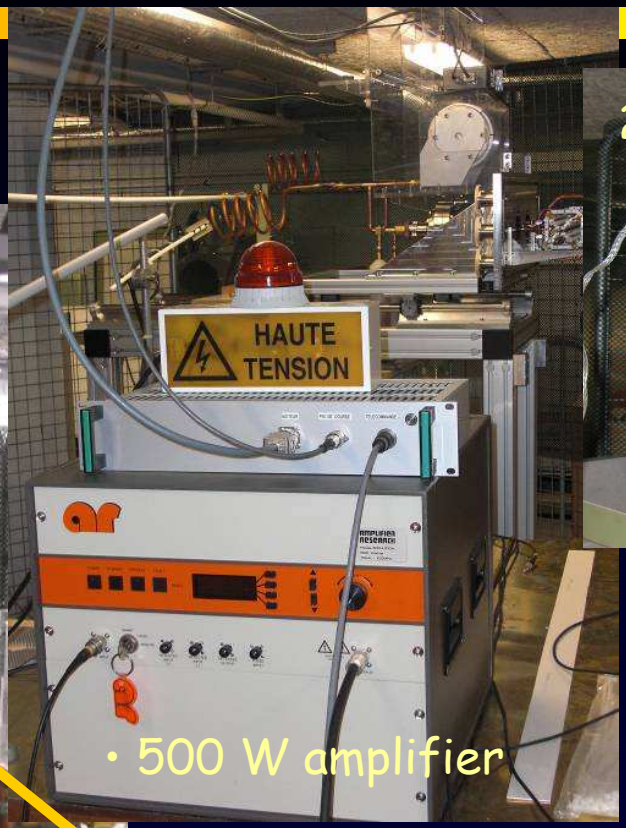
RF system layout



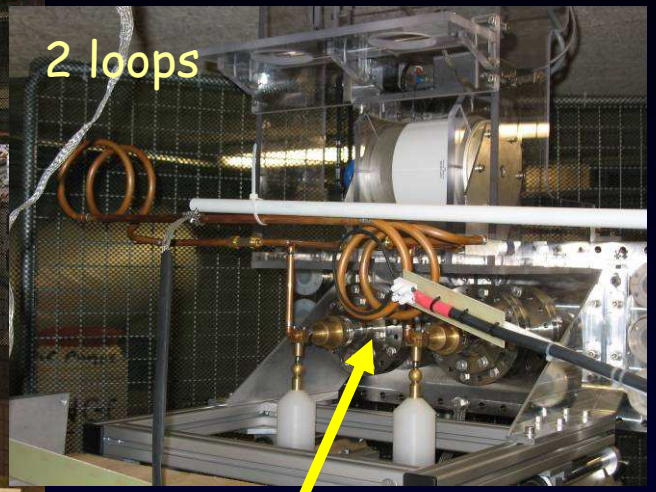
- Resonance Frequency tunable via adjustable capacitor
- No ferrite cores for the inductive coupling with amplifier
- DC potentials for the segments guided inside the coils (no HV filters)
- Asymmetries compensated mechanically by translation of middle point

High Voltage RF Developments





• 500 W amplifier

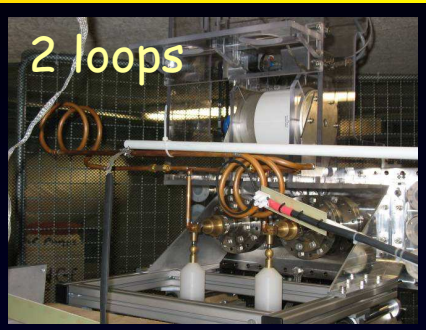


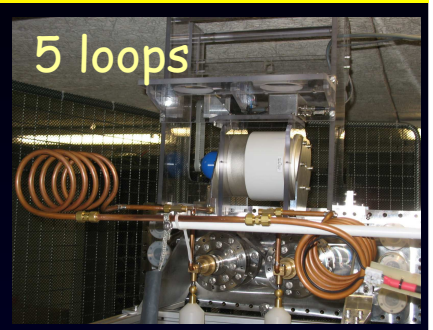
• Resonant circuit with Inductive coupling (no ferrite cores)

• HV Tunable capacitor for broadband use

RF performances and limitations

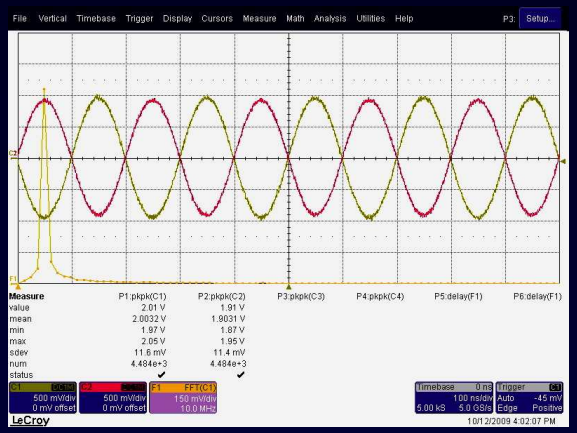
- 9 MHz 5.8 KV 2 loops secondary





- 6.5 MHz 8 KV 5 loops secondary

- Highly Harmonic

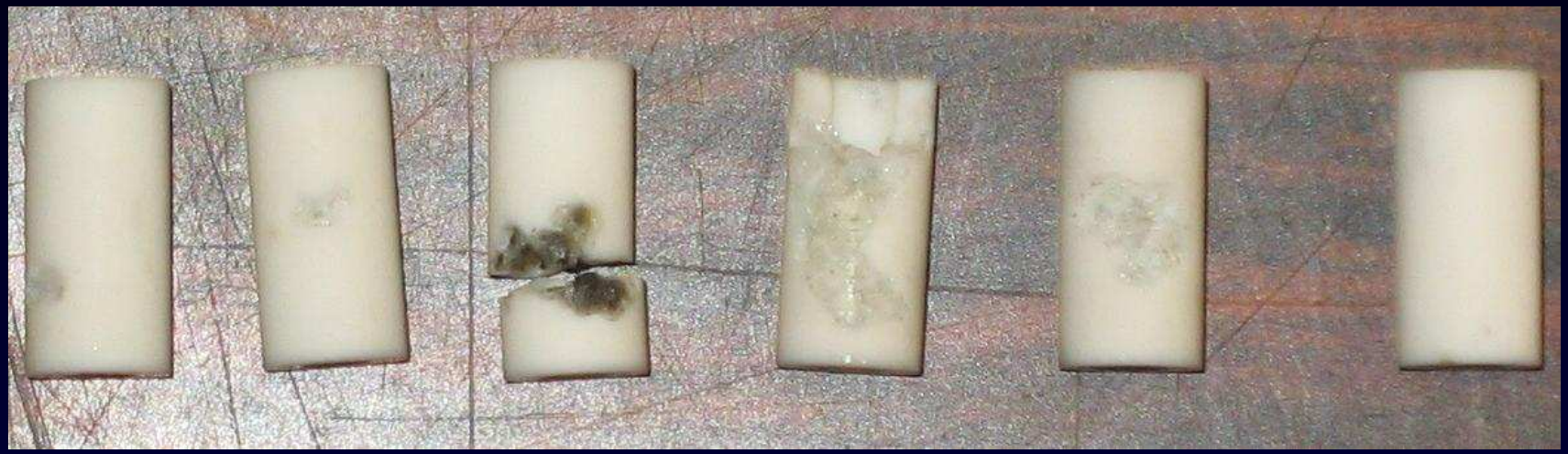


- Present limitations:

à INSULATOR Breakdown at ~8 kV…

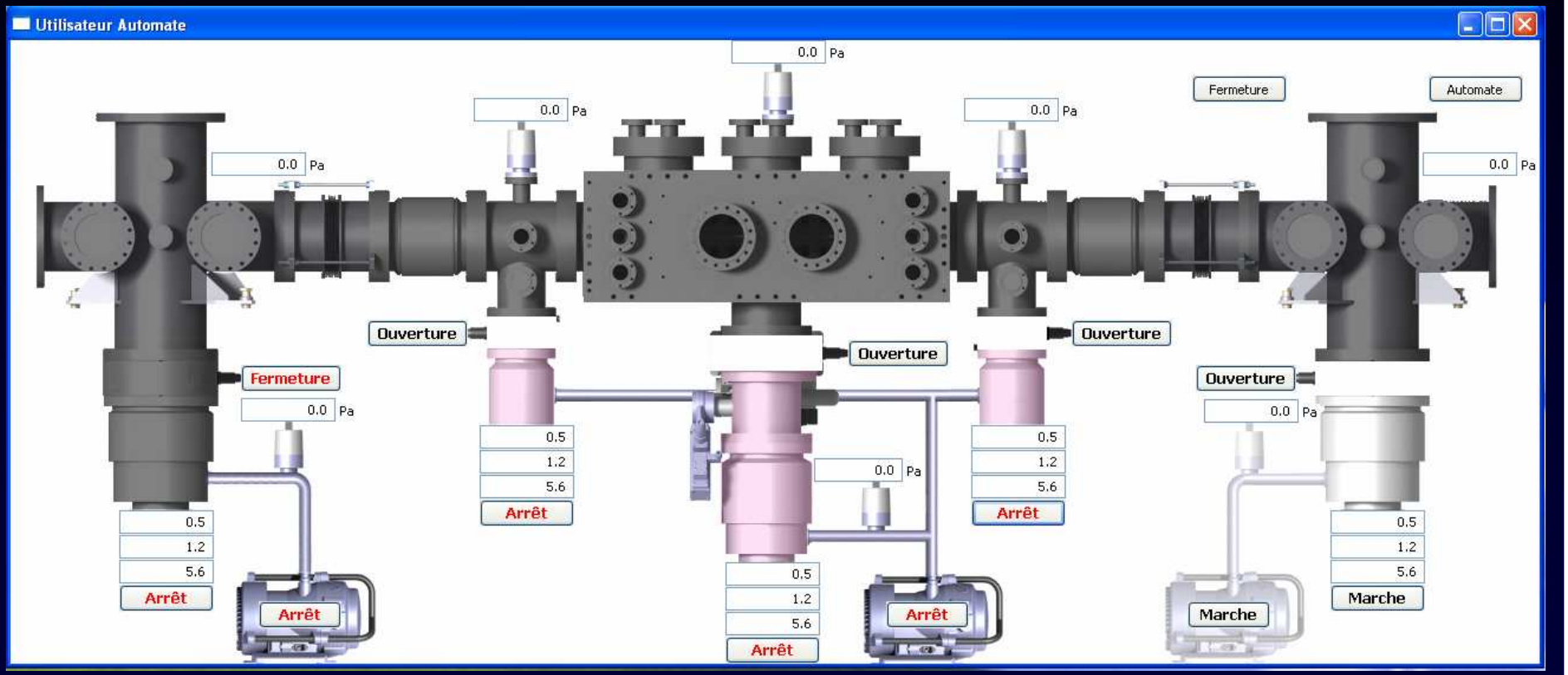
Investigations underway à improved design and new materials needed (PEEK)

Insulator burning VRF~8 kV

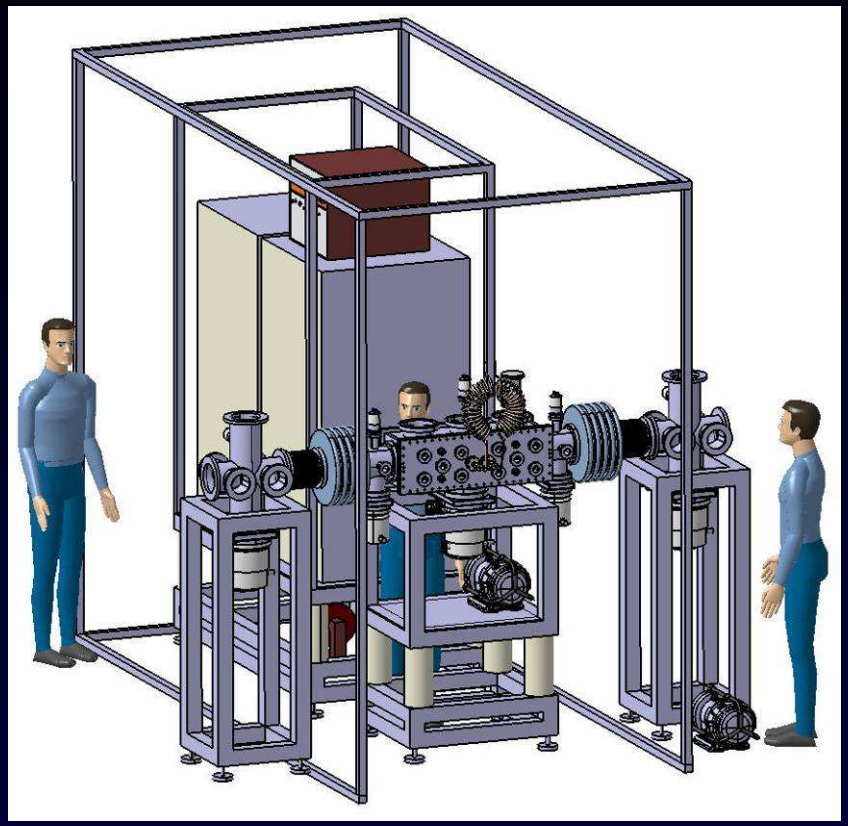


~7 mm

Slow Control (vacuum system, RF, DC, gas…)



LPC SET UP in 2010



From Drawings to reality…

To be done…

- Completed in April 2010
- Test with high intensity beams
- Adaptation to Nuclear environment

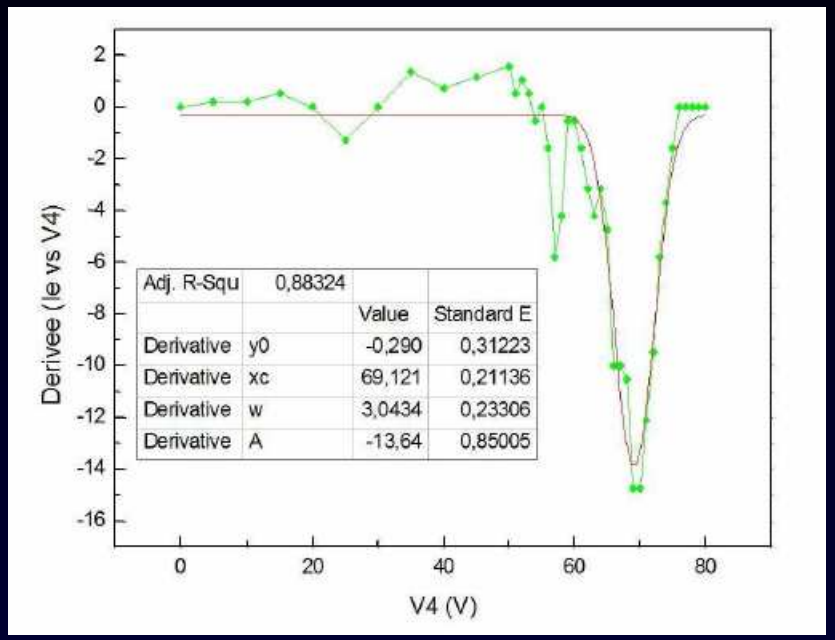
Overview and outlook

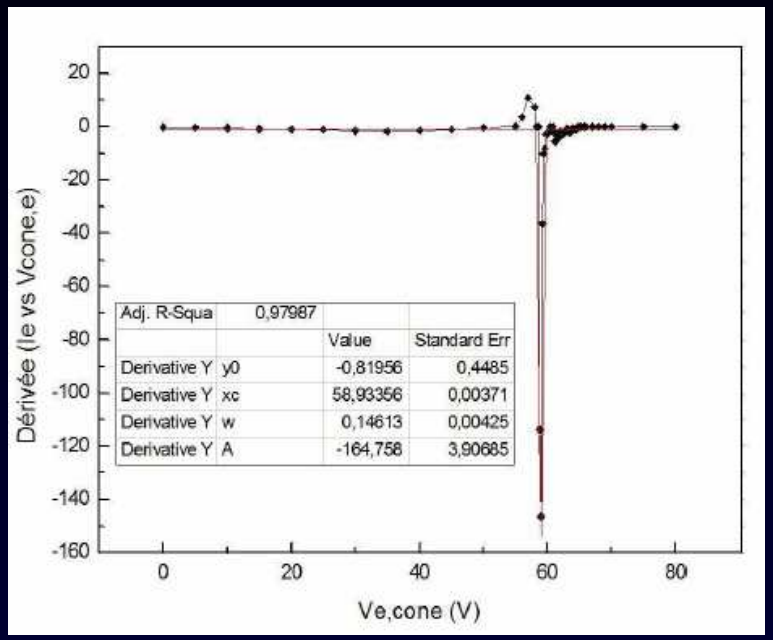
- Work on a 1st prototype
  - Emittance within requirements
  - Transmission (25%) limited by acceptance (to be improved)
  - Simulation code validation
- RF system ~ OK, higher HV and RF requires new design and new materials
- Construction of SHIRaC2 , mechanics, slow control, vacuum system, safety, RF system…
- Setup almost completed in April 2010
- Cooling of μA beams For HRS requirements to be confirmed in 2010

Spiral II set up and interface with HRS


S2WS
Spiral2

Longitudinal enery spread





No cooling
ΔE=3 eV

Cooling
ΔE=0.145 eV

Validation of simulations
Transmission ~25 %
Limited by acceptance